Adjuvants can be defined by how they are combined with pesticides in these two ways:

**Formulation adjuvants** are already included as part of the pesticide product by the manufacturer when it is made.

**Spray adjuvants** are separate products that are added to a pesticide spray solution by the applicator.

Since applicators have no control over formulation adjuvants, this publication focuses on those products classified as spray adjuvants.

With so many adjuvant products currently in the marketplace, how do you make an informed decision about which adjuvant to select and use for a particular situation? The best way is to have a general understanding of the basic characteristics associated with the various groups of products found among these diverse chemistries.

Before using any adjuvant, check the pesticide’s label. Many pesticide product labels have sections specific to the use of adjuvants. Other products may reference adjuvant use as part of the overall information found in the “Directions for Use” section, while some may not reference their use at all. In many cases, the label directions must be followed. Failing to do so would be a violation because label directions were not followed.

Adjuvants do not have any pesticidal activity, but they are chemically and biologically active products that can have health risks. These products will have a signal word on their label distinguishing the level of toxicity, just like pesticides.

If you have questions about the specific properties or use of an adjuvant or pesticide, contact the manufacturer or the dealer where they were purchased before attempting to use them. Manufacturers and pesticide dealers can provide labels, technical information, Safety Data Sheets (SDS), supplemental labeling, and promotional literature about their products.

**Adjuvants and Spray Application**

Adjuvants are designed to perform specific functions involving the mixing and application of pesticides, such as buffering, dispersing, emulsifying, spreading, sticking, and wetting. Adjuvants can also reduce evaporation, foaming, spray drift, and volatilization. No single adjuvant can perform all these functions in all situations, but different types of adjuvants can often be combined, or purchased as a prepackaged combination, to perform multiple functions.

As a result, using adjuvants can help minimize spray application problems along with increasing a pesticide’s effectiveness.

Spray adjuvants can be further broken down into two groups: activator adjuvants and special-purpose adjuvants, which are also called utility adjuvants or spray modifiers.

**Activator Adjuvants**

Activator adjuvants are designed to improve the “activity” of the pesticide, typically by increasing its absorption rate and reducing the surface tension on the leaf. Activator adjuvants include surfactants, oils, and nitrogen-based fertilizers.

**Surfactants**

Surfactants (whose name comes from “surface acting agents”) physically change the properties of the spray solution and droplets. They help improve the pesticide’s ability to emulsify, disperse, spread, and stick by reducing surface tension (Figure 1). Leaf surfaces, as well as pesticides, have a molecular charge. A surfactant’s charge, or lack of charge, will determine how it bonds to a pesticide, which in turn affects how the pesticide will bond to the leaf surface. The goal of this process is to reduce surface tension, which increases a spray
droplet’s ability to remain in contact with the leaf surface longer, allowing more pesticide to be absorbed. The types of surfactants are based on their molecular, or ionic, charge (Chart 1). Effectiveness is based on environmental conditions, features of the target plant, and interactions between the pesticide, surfactant, and carrier.

**Oils**

The three types of oil-based adjuvants include crop oils, crop oil concentrates, and methylated seed oils. They increase the penetration of spray droplets and help reduce surface tension.

- **Crop oils** are generally made of 95 to 98 percent paraffin or naphtha-based petroleum oil and 1 to 2 percent surfactant/emulsifier. Crop oils promote the penetration of a pesticide spray either through a plant’s waxy cuticle or an insect’s tough, chitinous shell. Traditional crop oils are more commonly used for insect and disease control and rarely with herbicides.

- **Crop oil concentrates (COCs)** are made up of 80 to 85 percent emulsifiable petroleum-based oil and 15 to 20 percent nonionic surfactant. Crop oil concentrates have the penetration properties of oil and the spreading properties of a surfactant. They also help make some of the less-soluble herbicides more soluble in water.

- **Methylated seed oils (MSOs)** are made up of 80 to 85 percent crop-derived seed oil (cotton, linseed, soybean, or sunflower oil) and 15 to 20 percent nonionic surfactant. To improve their performance, many MSOs have undergone a process called esterification, which changes a seed oil’s characteristics, so it is attracted to and can be dissolved in water. MSOs work in the same manner as traditional crop oil concentrates by increasing the pesticide’s ability to penetrate the target pest.

**Nitrogen-based Fertilizers**

The use of nitrogen-based fertilizers, such as ammonium sulfate or urea-ammonium nitrate, as adjuvants has been shown to help improve herbicide activity when used in the spray solution. Nitrogen fertilizers may replace some adjuvants, but they are usually included as part of the tank mixture with a surfactant and a crop oil concentrate when used with systemic pesticide products. Many fertilizer-based adjuvants are available in liquid form, which are easier to mix and provide more consistent results. Fertilizers should only be used with herbicides when recommended by the label.

**Special-Purpose or Utility Adjuvants**

Special-purpose adjuvants fix specific conditions that can affect the spray solution or the application of the pesticide in a negative way. By controlling these factors, you can maximize the efficient use of the pesticide. One group of special-purpose adjuvants modifies the physical characteristics of the spray solution and includes products such as compatibility agents, buffering and conditioning agents, defoaming agents, deposition agents (stickers), and drift control agents. The second type of special-purpose adjuvants helps minimize application problems and includes products such as foam markers, tank cleaners, and colorants. Carefully follow product label directions before adding any adjuvant to a spray mix.

**Compatibility Agents**

Pesticides are commonly mixed with liquid fertilizers or other pesticides. However, some combinations can be physically or chemically incompatible, which may cause clumps to form or products to separate in the spray tank. As a result, incompatible mixtures can clog the pump and hoses, resulting in expensive cleanup and repairs. Using a compatibility agent may eliminate these

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**Chart 1: Classification of Surfactants**

Surfactants are classified by the way they ionize, or split apart, into electronically charged molecules called ions. These ions are made up of a water-loving head (hydrophilic) and an oil-loving tail (lipophilic), which will have either a neutral, positive, or negative charge. This enables the surfactant to bond with the spray droplets, allowing the spray droplet to stick and spread out over the leaf surface. Only use the type of surfactant listed on the label.

The three main types of surfactants are classified by their molecular makeup:

1. **Nonionic surfactants (neutral/no charge):** most commonly used type of surfactant and typically recommended for use with most registered pesticides
   - Help with spray droplet retention, spreading, and penetration of leaf surfaces
   - Composed of alcohols and/or fatty acids and are compatible with most pesticides
   - Pesticidal activity can be quite different than if an anionic or cationic surfactant was added

2. **Anionic surfactants (negative charge)**

3. **Cationic surfactants (positive charge)**

The last two surfactants are not generally used with pesticides.

A newer group of surfactants is being used in place of or in addition to traditional nonionic surfactants:

- **Organo矽 surfactants:** reduce surface tension, increase spreading ability of spray droplets, and improve rainfastness (amount of time needed between pesticide application and rainfall)

Using the wrong surfactant can reduce the effectiveness of a pesticide product and increase the risk of plant injury. Always check the product label to see if using a specific type of surfactant is required or recommended.
problems. A “jar test” (Chart 2) can help determine the stability of the mixture.

**Buffering and Conditioning Agents**
Most herbicides, insecticides, and fungicides perform best in slightly acidic water that has a pH range of 4.0 to 6.5, with an ideal range of 5.5 to 6.5. The exception is sulfonylurea herbicides, which perform better in water with a pH of 7.0 or above. Pesticide solutions with a pH level above 7.0 are at greater risk of degrading or breaking down. In some cases, a pesticide that is stable in water and has a pH level of 5.0 can lose half of its effectiveness in as little as 15 minutes if the water’s pH is 9.0. Acidifier adjuvants lower the pH of the water in the spray tank, although they do not necessarily maintain that pH level at a constant rate. Buffers tend to stabilize the pH at a relatively constant level.

Conditioning or water-softening agents reduce problems caused by hard water. Minerals found in hard water, especially calcium and magnesium ions, bind with the active ingredients of some pesticides, which may decrease their performance. Before using a buffer or conditioning agent, consider the specific requirements for the pesticide and test the water for pH and hardness.

**Defoaming Agents**
Defoaming agents are added to the spray tank to control or reduce the formation of foam in the tank. Foam is created when air bubbles form as a result of spray tank agitation, along with the type of surfactant used to formulate the pesticide.

**Deposition Agents**
These adjuvants, often referred to as “stickers,” increase a pesticide’s ability to stick to a target’s surface. This decreases the amount of pesticide that washes off the surface during irrigation or rain. Deposition agents can also reduce a pesticide’s evaporation rate and some products can slow a pesticide’s degradation from ultraviolet rays. Many deposition agents also include wetting agents to make a premixed product that both spreads and sticks to the target surfaces.

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**Chart 2: Jar Test for Compatibility of Pesticide Mixtures**

Always wear personal protective equipment (PPE) when pouring or mixing pesticides, even for this simple test.

To conduct a jar test, use a clear quart jar and add proportionate amounts of all the products to be mixed into the spray tank. When a liquid fertilizer is to be used as a carrier, many herbicide labels recommend using two jars for this test—one with and one without a compatibility agent.

**Step 1.**
Measure 1 pint of water (or carrier solution) into a clear quart jar. Use the same water source that will be used for making the tank mixture.

**Step 2.**
Add proportionate amounts of each product as planned for the tank mixture, one at a time, in the order referenced on the label, or if not listed on the label, add ingredients in the following order. Stir the mixture each time a product has been added.

1. Compatibility, buffering, or defoaming agents (if needed)
2. Wettable powders, dry flowables, water-dispersible granule products
3. Flowables, liquids, microencapsulated products
4. Solutions, soluble powder products
5. Remaining adjuvants, such as surfactants or crop oils (if needed)
6. Emulsifiable concentrates

**Step 3.**
Shake the jar vigorously and allow it to stand for at least 15 minutes before looking for signs of incompatibility. The mixture is probably not compatible if a scum forms on the surface, the mixture separates, solids form and settle to the bottom (except for wettable powders), or clumps or gels form. Also look for other signs of a chemical reaction, such as heat or strong odors. Do not use a mixture that gives off heat, which is determined by feeling the jar. A strong odor indicates that a chemical reaction has occurred, changing the product’s chemical properties. If a compatibility problem occurs, dispose of the mixture according to the pesticide product label.

Finally, if no signs of incompatibility appear, put the pesticide test mixture into the spray tank. Rinse all jars and devices used for measuring, pour the rinse water (rinseate) into the spray tank, and then apply to a labeled site. Do not use measuring devices or jars for any other purpose once they have been used with pesticides.

**Drift Control Agents and Thickeners**
Drift is a function of droplet size, wind speed, and height of the spray boom. Small droplets (with diameters of 150 microns or smaller) tend to drift from targeted application sites. Drift retardants or deposition aids improve on-target placement of pesticide sprays by increasing the average size of droplets. These adjuvants bind water molecules together to form larger spray droplets.

Thickeners, as the name suggests, increase the viscosity (density) of spray mixtures. These adjuvants are used to control drift or slow evaporation of spray droplets after the spray has been applied. Slowing evaporation is important when using systemic pesticides because it increases the time in which they can be absorbed by the plant.

**Foam Markers**
Foam markers are adjuvants designed to produce a foam mark when used with special equipment, so the applicator knows where the product has been applied. This helps the applicator avoid skipping areas and/or overlapping areas already sprayed.

**Tank Cleaners**
As the name implies, tank cleaners are designed to clean spray tanks. Commercial tank cleaners are adjuvants designed to work with water and oil-soluble pesticides. These products are often recommended on pesticide labels.
**Colorants**

Colorants are used to change the color of spray solutions, so applicators can easily see areas that have already been sprayed.

**Suspension Agents**

These products extend the amount of time a pesticide will remain suspended in the mixture. If agitation is stopped for a time, this product aids in resuspending the mixture when agitation is restarted.

**Adjuvant Acronyms**

The following are common acronyms used in association with adjuvants:

- **AMS**: ammonium sulfate; a common water-conditioning agent for hard water
- **COC**: crop oil concentrate; adjuvants primarily derived from plant seed oils, with the remaining amount a nonionic surfactant
- **MSO**: methylated seed oil; adjuvants primarily made of industrial products or household horticultural uses. Do not use adjuvants with pesticides because they may interfere with or reduce pesticide performance.
- **NIS**: nonionic surfactant

**How to Choose the Right Adjuvant**

Remember, the purpose of adding an adjuvant is to improve a pesticide’s performance and/or change a pesticide’s characteristics to minimize problems when mixing and applying. Many factors must be considered when choosing an adjuvant. The following are some guidelines:

- First and foremost, **read the pesticide label**.
- Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides because they may interfere with or reduce pesticide performance.
- Be aware that some adjuvants may be more toxic than the pesticide. Choose the least toxic adjuvant that meets your needs.
- Pesticide labels seldom mention specific brands of adjuvants but rather the general type of adjuvant, such as nonionic surfactant, crop oil, or defoaming agent. However, if the pesticide label lists a specific brand of adjuvant, that brand must be used. Any substitution would be a violation of the label.
- Miracle adjuvants do not exist. Ignore claims such as “keeps spray equipment clean” or “causes better root penetration.”
- Always buy high-quality, name-brand products from a reputable dealer.
- Adjuvant recommendations may change due to changes in pesticide formulations, newly labeled tank mixes and premixes, and changes in application technology and procedures. **Always read the label every time a pesticide product is used**.
- Using an adjuvant is not always necessary. Knowing when not to use an adjuvant is just as important as knowing when to use one. Some pesticide labels may state that an adjuvant should not be used with that particular product. If the label does not mention an adjuvant, the manufacturer’s research may have shown no benefits—or even the occurrence of adverse effects—from using an adjuvant.

**Spray adjuvants can play a major role in the safe and effective use of pesticides when used as recommended on the label. Although a single adjuvant may perform more than one function, no single product can improve the performance for all pesticides or solve every problem. As a result, many spray adjuvants are available, each formulated to solve problems associated with a particular type of application or situation. **Read the pesticide label**.

The correct use of adjuvants requires knowledge of the site you plan to spray, the target pest, your equipment, water chemical, environmental conditions at the time of application, and the pesticides you plan to use. By knowing the particular needs and limitations of the products you intend to use, adjuvants can be a positive addition to the spray tank.

**References**


